FAST VISION ALGORITHMS FOR ADVANCED DRIVER ASSISTANCE SYSTEMS

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Motivation of the work:

The number of road traffic deaths – 1.25 million in 2013 – has plateaued since 2007 despite the global increase in population and motorization and a predicted rise in deaths. This suggests that interventions implemented over the past few years to improve global road safety have saved lives. [1]

ADAS (Advanced Driver Assistance Systems) have made a great contribution to improve the road safety in the last years.

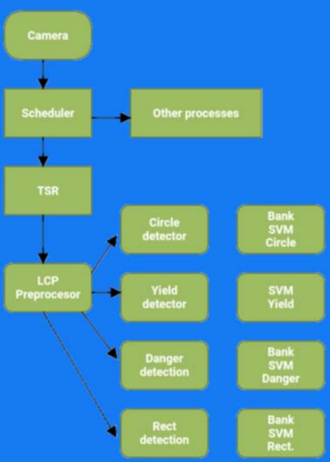
The autonomous vehicle (according to SEA) are classified in the 6 categories from level 0 to 5. Today self driving systems are between level 2 and 3. But the goal is to achieve fully autonomy (level 5) in 2021 [2], even Elon Musk says that Tesla is 2 years away from that goal [3].

Computer vision is cheaper than other technologies used in ADAS like Radar, laser (LIDAR) [4] or has better performance than others like ultrasound.

The drivers use vision as their principal sense in the driving process, so **computer vision** is the natural way to perceive the environment.

But many state of the art computer vision algorithms used for ADAS are not capable of **real time processing** (the algorithm in [5] runs at around 2.5 Hz on an Intel Core i7 870 with a Nvidia GeForce GTX 470 GPU) or can´t be implemented in car computers (CPUs, DSPs, FPGAs or the new systems based on GPUs [6]). Moreover, many of these systems don't work in real driving conditions as rain, strong shadows, fog, road degradation or partially occluded objects.

So there is still an inherent need for developing **computer vision algorithms** that can work in real driving conditions and in real time.



Thesis Objectives

Adapt state of the art algorithms to ADAS working in real time.

There are algorithms with a good performance but they can´t work in real time or embedded in a car because of high computation cost or power requirements. Sometimes they are implemented in cars but with performance loss.

Develop new algorithms for ADAS that work in real time.

There are ADAS based in computer vision that detect lines, traffic signs, pedestrian, vehicles or another kind of objects. Some of them are implemented in commercial vehicles today, but there are a lot of room to improve their performance. New algorithms to help the autonomous driving in urban scenarios will be needed in the future. I have developed a first implementation of a surround view system that will help drivers in parking manoeuvers and driving at low speed. Future implementations will improve the interface with the driver and add other points of view. Also, I will consider SFM (Structure From Motion) algorithms in urban scenes to determine paths where the car can move and real distances to objects. The point clouds that we can obtain from a SFM can also help other ADAS to achieve real time speed and better performance.

Compare the performance with other ADAS non based on computer vision.

There are ADAS that can also use technologies not based in computer vision. For example, line keeping assistant system can rely in LIDAR or computer vision, or obstacle detection systems can be laser, radar, ultrasound or camera based. As mentioned in the motivation work, some technologies are more expensive than computer vision, but a comparative of the performance of the systems is necessary to adopt one or another.

Study of new hardware parallel architectures (GPUs and FPGAs). Study the adaptation of algorithms

New computer systems to be implemented in cars are emerging today. GPUs are a hot topic today and their manufacturers are paying great attention to the automotive market. So, algorithms that today may not work in real time will achieve real time performance with the use of GPUs.

Research Plan

All algorithms developed for this thesis will be implemented and tested in a common platform for better evaluating the results. This platform has been almost developed this first year. The GPU part will be developed in the third year of the planning. The platform is also used to present information to the driver. The algorithms in research stage will be tested in the platform as soon as they are optimised to work in real time.

Ground truth data for computer vision algorithms will be obtained using other technologies or hand labelled scenes. These data will allow to compare the performance of computer vision based ADAS with other technologies.

The table at right shows the detailed research plan.

Research Plan	NMonths	Year1		Year2		Year3	
		S1	S2	S1	S2	S1	S2
Literature Review	3	2		1			
Analisys state of the art	4	2		1		1	
Development of a global platform to test algorithms	5	2	2		1		
Adapt state of the art algorithms	7		3	1	1	1	1
Develop new algorithms	8		1	1	2	2	2
Compare to other technologies	5			2	2	1	
Study of GPUs and adaptation of algorithms	4					1	3

Results & Discussions

Use of the previous developed surround view system to detect neighbouring lanes in the lane systems of the ADAS.

The surround view system was initially developed to help the drivers in the parking manoeuvres, but another interesting use is to help the lane keeping assistant system to detect the lines parallel to the ego lines.

Study of different machine learning and deep learning classifiers for the TSR system in CTAG

I have developed a bank of SVM classifiers for different types of traffic signs (yield, danger, mandatory). Now we are comparing the performance (at CTAG) in real world scenarios with our previous classifier (only mandatory ones) and with other implementations. Our performance is inferior to state of the art algorithms, but including real time requirements our performance is comparable to other commercial systems. (Mobileye)

Start to implement a Structure From Motion (SFM) module

This module will be used to determine the free-space (drivable area) where the autonomous car can plan its motion. I´d developed the first stage of the module, the determination of the homography between the images which determine the movement of the car frame to frame. There is no 3D points for the moment and I´m analyzing different interest point detectors to improve real time and reduce the computational complexity.

Next Year Planning

Continue the development of a SFM module.

Next stage is to obtain the 3D point cloud and process this 3D structure to determine the presence of objects (cars, pedestrians, motorcycles, etc.) and the drivable area.
The goal is to develop a real time system, there are several SFM modules but they lack of having a great complexity to be integrated in car electronics.

Compare the performance of ADAS based in computer vision with other systems

I´m involved in the development of a new low cost LIDAR system, when the system is finished I will be able to compare the performance of both systems. Current LIDAR systems are more precise, but they are much expensive that computer vision systems.

Prepare an article comparing our real-time TSR system (both detector and classifier) with state of the art algorithms and systems

References

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